

Essays in Economic & Business History
2023, 41 (1): 55-79
Published April 22, 2023



The Audio Compact Disc: A Business History Case

Lee Yoong Hon, Nottingham University Business School, University of Nottingham Malaysia, lee.yoong-hon@nottingham.edu.my

Abstract

The audio compact disc (CD) has been a common item in most households ever since its introduction in the early 1980s. A pioneer format in digital music, it captured the imagination of many at the time of its inception. In this article, I present the CD as a business history case, from being a unique innovation to its commercialization. While its introduction significantly disrupted the market for recorded music, its eventual success and acceptance underscores its immense profitability to the industry, one which was built on a business model of music rights exploitation. Meanwhile, the CD's marketplace dominance is evidenced by data from the US and Japan. Although CDs dominated their markets throughout the 1990s, the format is now on its last legs. However, the CD, as a cultural product with nostalgia value, is likely to enjoy an extended product life cycle long after its market exit.

JEL Classifications: L82, N80, Z11.

Keywords: music industry; music format; audio compact disc; cultural product.

Copyright © 2023, The Economic and Business History Society. This is an open access journal. Users may read, download, copy, distribute, print, search, or link to the full texts of the articles in this journal without asking prior permission from the publisher or the author.

ISSN 2376-9459 (online) LCC 79-91616 HC12.E2

<http://creativecommons.org/licenses/by/4.0/>



Introduction

The music industry has come a long way since the invention of the gramophone over a century ago. Popular music has been delivered in many physical formats since then, from vinyl records to the 8-track, the compact cassette, the audio compact disc (CD), and so on. While the new digital era has all but ushered out these formats, their relevance and continued influence remain interesting from both business and cultural perspectives. For example, the uniqueness of these products (being cultural goods), has seen their “return” years after their exit—both vinyl and cassette have staged comebacks in recent times. In the case of vinyl, its recent comeback phenomenon has made headlines in the news media and stoked considerable interest in academia as well. Considering that the format has been around since the earlier half of the twentieth century and the industry having undergone several rounds of technological innovation (“disruptions”) in terms of music format, the vinyl revival has been impressive, to say the least. The focus of this article, however, is on the CD.

In recent times, music is increasingly delivered virtually via the Internet—from digital downloads to the streaming of music. Unsurprisingly, the CD, as the incumbent physical format, is being displaced in the market at a rapid pace it is likely that CDs will completely disappear from the market soon, a phenomenon that is not dissimilar from the experiences of other recorded music formats. In 2020, the share of sales volume of CDs in the US recorded music market was a paltry four percent, a far cry from its glorious years when its market share once easily exceeded 90 percent.¹

In the case of physical music formats, the mainstays have been vinyl, cassette and CD, with each dominating the mainstream market at one point or another. The LP was introduced by CBS in 1948 although it was not until the 1960s that the album format became the popular form of it.² Next came the magnetic tape cassette, introduced to the market in the mid-1960s, while the 8-track cartridge would also mark its entry in the 1960s. From the 1970s onwards, cassette emerged as the dominant format (this continued well into the 1980s) and was especially popular in some parts of the world, namely the South-East and East Asia region. The baton would next be passed over to the CD, a joint invention by Philips and Sony, first introduced to the public in the late 1970s.³ Although the CD was commercially launched in 1982, it only took off in the mid-1980s but quickly became the key music format of the industry, this by the early 1990s. Its replacements, i.e., digital downloads (later, streaming), can be traced to the late 1990s following the internet revolution, although it would take at least another decade before they dominated.

These format changes exemplify Joseph Schumpeter’s classic concept of “creative destruction”, in which an incumbent makes way for a superior substitute (Schumpeter 1942). For example, one reason why cassette replaced vinyl, despite its obvious inferior sound

¹ The CD’s market share in terms of US sales volume went as high as 93.4 percent in 2002 and 2003 while hitting 95.5 percent market share in terms of total revenue in 2002 (RIAA).

² This version, the one that most people would identify vinyl with, essentially consists of between 8-12 songs. The other would be the vinyl single which comes with only 1-2 songs (i.e., the 45s), popular with young listeners who were attracted to just the hit singles (songs). Before the introductions of the LP and 45s, the 10- and 12-inch shellac 78 RPM (revolutions per minute) disc record was the dominant format. These 78s were coated with shellac, and hence known as shellac records. Although 78.26 RPM was chosen as a standard for motorized phonographs in 1925, these shellac records were still referred to as just records although after World War Two, the need for distinction arose given the existence of other newer disc record formats. Shellac 78s continued to be produced despite the existence of other newer formats, but were discarded by the mid-1950s (Yale University Library).

³ Sony first publicly demonstrated their optical digital audio disc at the 1977 Tokyo Audio Fair. Philips demonstrated a 11.5 cm optical disc accompanied by the audio player to the international press in March 1979 although the final version of the CD’s diameter would measure 12 cm. See Philips Research for more.

quality, was due to its greater portability compared to vinyl; cassettes could be easily played in car stereos or personal audio players such as the Sony Walkman. CDs then replaced cassettes, given their superior sound quality whilst being just as portable and allowing easy replaying and switching between songs. Finally, digital downloads and music streaming have replaced CDs—they are even more portable and boast of significantly greater storage space (with virtual access to thousands of songs).

The explosion of the internet, while setting the stage for the dominance of streaming/downloads, also saw many adverse disruptions to the industry, including the illegal downloading of music and, later, the controversial peer-to-peer (P2P) file sharing, a practice that was eventually deemed illegal.⁴ As each new format previously saw opportunities to exploit the music rights (for example, re-issuing an album or releasing a greatest hits album) but also threats (for example, music taping at home was seen as a big threat to the industry in the early 1980s), it is not surprising that stakeholders tend to be cautious each time a new format is being touted. In fact, Peter Tschmuck (2017) argued that the recessions in the UK recorded music market in 1980 and 2005 were the result of format change, the former saw transitions from vinyl to cassette (though it was also around the time of the second oil crisis) and while the latter, CDs to digital downloads. Further, Terry Gourvish and Kevin Tennent (2010) identified two other slumps in the UK music industry in 1957-59 and 1964-66.⁵ Curiously, the former period marked the beginning of shellac's steep drop but 45s' sharp rise while the latter witnessed the beginning of 45s' fall but LPs' continued surge. On the other hand, format change could also offer new opportunities for the industry to generate additional profits. David Arditi (2014) argues that record companies generate profits through "album replacement cycles" while Constantinos Markides (2006) likens the music industry to one where the players' existence hinges on their ability to introduce new creative products continuously.

Further, in some cases, the linkage between the music industry and its parent, the electronics industry, is another factor in that the music was complimentary to the music equipment/hardware, the latter proving to be just as lucrative—Philips and Sony, being also hardware makers, are good examples. In fact, in the 1960s pre-CD era in the UK, the music industry was characterized more by being a branch of the electrical industry—the early players like EMI and Decca originally entered the industry as gramophone hardware producers. Similarly in this period, the records were oftentimes sold at electrical shops as opposed to specialist music retailers (Tennent 2013). Of course, these companies would later extend their vertical boundaries into other stages along the production chain, namely manufacturing (i.e., records), distribution and retailing, paving the way for better control and, of course, greater profitability. By the time of the CD's arrival in the 1980s, the major companies, especially those involved in manufacturing the hardware and software, were again in the position to dominate the business and generate profits, for example by exploiting music rights again via releasing back catalogues in CD format.⁶ This phenomenon underlines the extended shelf life of music/albums via format changes which no doubt continues with the new format of music distribution today.

⁴ See the case of Napster, the most famous P2P file-sharing internet software which at one point facilitated the sharing of music files among up to some 50 million users before litigation and lawsuits put an end to it.

⁵ Based on falling total (recorded) music production in the UK—it fell in 1965 and 1966 before rising again in 1967. The rising trend continued until 1979, the next slump being the 1979-80 period. In any case, part of the reason for the 1964-66 slump was due to a significant drop in the production of the 45s. See Gourvish and Tennent (2010) for more.

⁶ On the basis of the three clauses of exclusivity in a recording contract, the record company/label can monopolize the exploitation of recorded music (Peter Tschmuck 2009).

Objective of this Article

Given the unique characteristics of physical music formats and the prominent role they played in the evolution of the music industry, I believe the topic of music formats warrants a re-visit. In this article, I look at the case of the CD. While there are plenty of academic papers on vinyl, few have explored the contribution of the CD to the industry, whether in the economic/business history sphere or from a cultural viewpoint, despite its prominence and legacy.⁷ This article aims to incorporate both the economics of CD production and the broader cultural role of the CD into an empirical understanding of the CD format now that its life cycle has all but ended.

This article's overall aim is to provide a historical account of the CD, from its introduction to its imminent exit. In doing so, I will present the CD as a business history case to illustrate the intricacies and processes surrounding the marketing and commercial release (and acceptance) of a product invention/innovation in the form of format change in the music industry. These discussions can also enhance the understanding of the evolution of the rights-based business model that has been so integral to the music industry and provide context to the digital streaming music distribution model we see today. The narratives presented in this article underline the significance of format wars and the dynamics surrounding network industries—format changes no doubt would allude significantly to the issue of complementarities between hardware and software development with the winner reaping huge rewards from the network externalities. The article will conclude with an assessment of the CD's overall success as an audio format and its cultural legacy.

This article employs a fact-based assessment approach and uses secondary data and various external sources (e.g., company histories, academic papers, music and tech magazines, newspapers and other websites) in forming the narratives of the CD format phase in the music industry, i.e., to make sense of the industry's experience with the CD and its place in the industry's history. In any case, the use of narratives is useful in constructing a judgemental rhetoric that can aid in making sense of a temporal chain of events (Tennent and Simon Mollan 2020). However, the analysis is restricted as there are limitations in industry data coverage.⁸ For example, data on music sales in the US are compiled by the Recording Industry Association of America (RIAA) but only from 1973. Therefore, the empirical analysis in the article is limited, mostly confined to interpreting descriptive statistics on key variables in the two largest national markets. Nonetheless, the discussions and interpretations of the data are cross-referenced and verified by reliable sources although many are on-line sources. This is largely the result of putting together and making sense of past events that stretched back many decades and the dearth of published material, both academic and non-academic. The quantitative data are taken from the RIAA and Recording Industry of Japan (RIAJ). I selected the US and Japan as they represent the biggest markets on either side of the world historically.⁹ Further, the selection is appropriate in that the more extensive time-series from the RIAJ compensates for the more restricted US dataset—this is important as the comparative analysis involves the dominant formats over several eras of the music industry. In addition, the idiosyncrasies of these markets also provide both an interesting and useful contrast to the discussions surrounding format dominance and longevity.¹⁰ Overall, this article

⁷ Ryan Daniel (2019) offers a good insight of the CD as a digital disruption to the industry.

⁸ Pekka Gronow (1987) cautioned on the accuracy of data in the music industry, stating that sales figures in certain countries may be limited to only IFPI (International Federation of Phonogram and Videogram Producers) member companies, while others, only estimates of total sales.

⁹ Other key markets would be UK and Germany, but data constraints led to their omissions from this article.

¹⁰ Reviews of Japanese-language literatures on the topic would certainly offer a greater perspective on the discussion—I believe such undertakings may be useful for future research on this topic.

offers a methodological contribution to understanding industries where archival availability is rather limited.

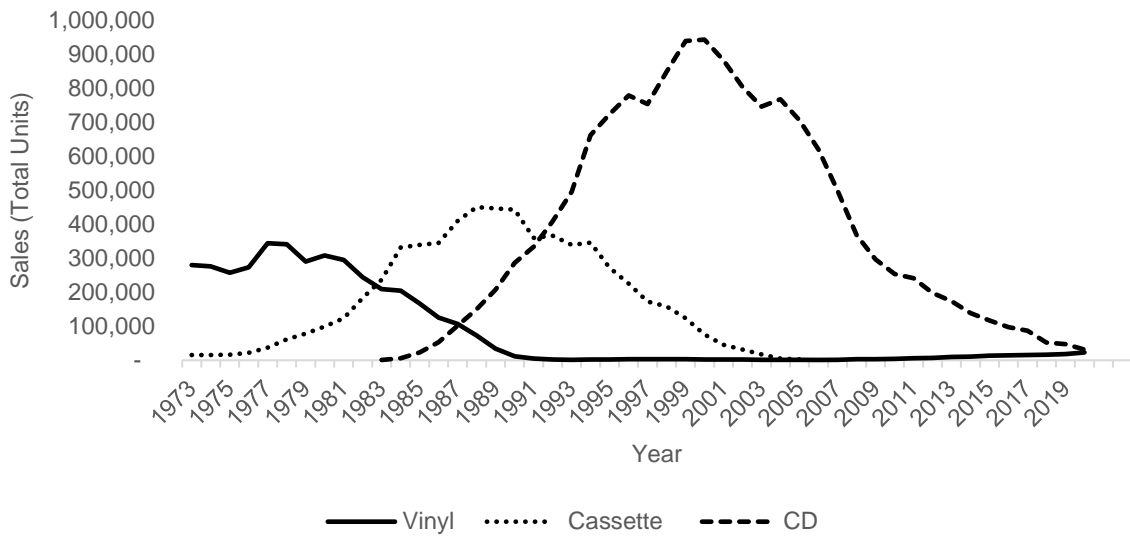
The CD: Some Background

The CD was invented in 1979 but was only formally introduced to the market in 1982. It was the product of the efforts of two technology giants, Philips and Sony. Both were working on their respective prototypes around the late 1970s but teamed up and eventually unveiled a standard final product, a thin shiny plastic disc with the capacity of storing up to 80 minutes of music. At the time, the CD represented a quantum leap in sound quality and storage capacity. Music consumers quickly adopted the product, which in so many ways was superior to the incumbents, the LP and cassette. As such, it was no surprise that the CD, with all its hype, was earmarked to replace its competitors when it was unveiled—it ultimately did, and in a big way too. Its demand eventually soared in the mid-1980s and by 1987, had achieved sales almost equal to those of the LP—close to 100 million were sold that year (Geoffrey Hull, Thomas Hutchinson and Richard Strasser 2011), a mere five years after it entered the market. It overtook the LP the following year and the cassette in 1991 (Ryan Waniata 2018). Figure 1 shows the total sales (in units) for the three dominant formats in the US from 1973 to 2020. The figure shows vinyl, cassette and CD each dominated for a certain period, but the domination of CDs lasted the longest. However, as data are available only from 1973 onwards, it is likely that vinyl's earlier dominant period is not fully captured. The more extensive timeline of Figure 2, showing the total sales (in units) for the three dominant formats in Japan, more adequately captures vinyl's dominance in the 1950s and 1960s. Nonetheless, in both cases, the CD's peak clearly overwhelmed the previous heights of both cassette and vinyl.

In essence, the iconic status of the CD came from being the first digital format (hence the term digital disruption¹¹), a feat of great symbolic importance in that it represented the second stage of music medium, a sophisticated pre-internet/streaming era at the time offering a vastly superior product (digital sound quality), ease of handling (its compact size) and much easier storage compared to vinyl. At the time it was nothing short of revolutionary: a technology that uses a laser (instead of a needle) to read the stored music data. Even as it was being touted as a medium that would ensure the perpetual lasting of one's music collection, it really did capture the imagination of many at the time when the world was at the cusp of rapid technological advancement and the market offered many technology-based consumer products from video games to the personal computer. Even pop culture at the time leaned heavily toward science fiction, for example, movies like *Star Wars*, *Star Trek* and so on. Thus, the CD, with its state-of-the-art outlook and packaging, was a wonder. By the mid-1980s, CDs would epitomize the materialist and consumerist culture at the time. Its steep pricing at the onset of its release meant CD-ownership symbolized success and made a lifestyle statement for the yuppie generation (Dorian Lynskey 2015). However, as with many innovations, the prohibitive introductory prices of both the player and the CD were temporary. Within two years of their release, the price of CD players in the US fell by 50 percent (Len Feldman 1984). Similarly, CD prices also fell significantly by the end of the 1980s—from a high of US\$21.50 in 1983 to just US\$12.22 in 1990. Meanwhile, the price of LPs in 1990 was lower at US\$7.39, but by 1996, both CD and LP prices were virtually identical—the CD's price being at US\$12.71 compared to the LP's price of US\$12.69.¹²

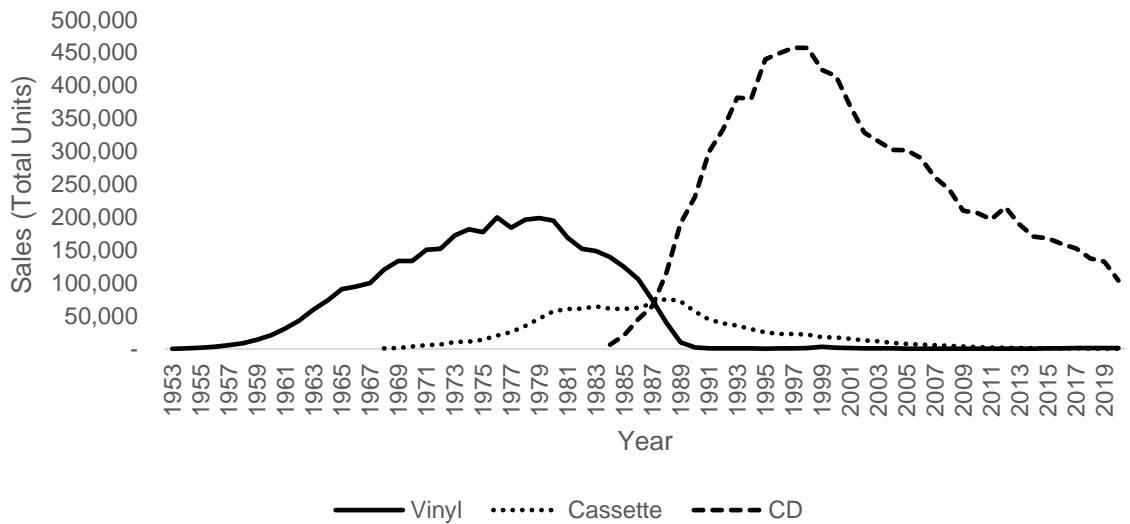
¹¹ See Daniel (2019).

¹² Based on my own computations of the average price (nominal) of CD and LP/EP using music revenues and sales volumes (by format) data (RIAA).



Source: Data Appendix Table 1.

Figure 1
Total Unit Sales of Vinyl, Cassette and CDs in US, 1973-2020



Source: Data Appendix Table 2.

Figure 2
Total Unit Sales of Vinyl, Cassette and CDs in Japan, 1953-2020

The CD: Invention to Commercialization

Development of the CD started in 1974 when Philips and its research laboratories embarked on the digital optical audio disk project although several others including Sony also undertook parallel works on such technology. While this was an ambitious undertaking, it was certainly not the only invention pursued with regards to music formats at the time. Over the following decades, many companies would introduce other unique inventions, but none came close to winning the format war and were eventually discarded. So how did the CD succeed and what were the pivotal factors that were at play? As with every format war, generic issues with regards to prices, product quality, compatibility and so on would be crucial but other factors like cooperation (with others) and marketing are also paramount. But more importantly, securing the support from key stakeholders in the market would prove to be the most critical element in format wars—this was the case of the CD and in other previous format wars, for example, the video tape wars in the 1980s and later, the DVD wars in the early 2000s. Interestingly, Sony was involved in all three episodes, underlining the company's innovative prowess.

Unsurprisingly, the disruptions in the music industry have largely been from the supply side—technological changes within the industry are synonymous with format changes, as potential business gains are enormous. In fact, recording companies may have played their part in expediting the demise of certain formats in the past (Laing 1992).¹³ This would not be surprising since the introduction of a new format would generate significant revenue; not just on selling records but also on the complementary hardware as well. The latter would explain the motivations of companies like Philips, Sony, JVC and so on, being producers of the audio players, to pour resources into research on and the development of new formats—for example, the cassette was the brainchild of Philips in the 1960s while Sony pursued the Mini Disc in the 1980s/early 1990s. Given the presence of network effects¹⁴ in such an industry, the competition was more about competing “for the market” rather than “in the market”, underscoring the enormous potential profitability in victory, i.e., a winner-takes-all outcome in such markets.¹⁵ For example, Philips, as inventor of the cassette, had enjoyed huge returns in terms of their music cassette player—the introduction of the then-new audio hardware in 1961 contributed significantly to its profits (Gerben Bakker 2006). However, from the consumers' perspective, format changes, despite their “superiority”, actually decrease consumer welfare, forcing them to duplicate their collections while also paying higher prices for the new format. Further, introducing the CD was a strategic move by record companies to extract another round of rights exploitation, indicating much of the total surplus going their way.

Although Philips and Sony succeeded in delivering the next technology that would “smash the equilibrium”, they faced intense competition, both from existing formats and new

¹³ This can be rationalized along the Durable Goods Theory, basically “planned obsolescence” by producers, i.e., the extent to which producers would introduce new products to make the older version obsolete. See Michael Waldman (2003) for an extensive review on the topic. In the case of vinyl, the tightening of terms with regards to the stocking of LPs systematically discouraged retailers to peddle more LPs. For example, Steve Hochman (1988) reported that PolyGram increased its returns penalty (surcharges when unsold merchandise is returned to the manufacturer by the retailers) on vinyl records thus discouraging retailers from stocking titles, especially the fringe ones.

¹⁴ “Network effects” refer to the increased value in a good or service when more and more people are using it.

¹⁵ In essence, competition for a market refers to the challenges of creating a new market, or to erect a new standard, and it is usually associated with the process of innovation that leads to a new replacement technology while the more conventional notion of competition, i.e., the competition in a market, is more about the actions of incumbents and imitative entrants in an already established market (Paul A. Geroski 2003). Format wars would apply to the former.

innovations. In the case of the former, CBS came up with the CX (Compatible Expansion) system, an electronic noise-suppression system that was able to eliminate the typical interference, thus raising the music sound quality that existing record players could deliver while removing the switching cost (Philips Research).¹⁶ Meanwhile, Telefunken developed its own digital disc format called the Mini Disc which, to their credit, did not require investments in new manufacturing facilities and purportedly had the same quality as the CD—it could even use the existing production inputs (pressings/other materials) as vinyl (Philips Research), removing the specific investment cost for the producers. Thus it appeared, at least at the time, that two reasonably value-creating options were on offer to music consumers.¹⁷ Such intense competition is not uncommon though—previous format changes also saw stiff contests between the players, in the case of the cassette, Philips’ compact technology against rival Grundig’s DC-International system, while for vinyl the format war was known as the “battle of speed”, essentially between the 33 RPM (LPs) versus the 45s (singles).¹⁸

Among the key stakeholders (i.e., the record companies, music publishers, artistes, music retailers, electronics retailers), the record companies were probably the most pivotal in the CD’s victory.¹⁹ Their initial reluctance was not surprising given the required investment outlay (e.g., new manufacturing and recording facilities) especially given the existing market with the vinyl (LP) format. But the CD was a superior product backed by the reputation of two world-class electronics giants (Philips and Sony) with sound reputations for innovation. Furthermore, Philips and Sony opted to make their technology available for a very low royalty, a move that all but ensured market standardization for their CD technology and, of course, won the market by virtue of the subsequent network effects.²⁰ As Brian Southall (2009) also recounts, the royalty payment was a key sticking point for EMI’s decision to adopt the format initially, but was overcome once they realized that the higher price of CDs would easily offset the royalty payments to Philips. Meanwhile, Philips and Sony published the Red Book on CD technical specification standards in 1980 and the technology was subsequently adopted by the Digital Audio Disc Committee in 1981, a committee appointed by Japan’s Ministry of International Trade and Industry to recommend a world standard for digital audio (Flamm 2013).²¹ Although two technologies were selected at the 1981 Audio Conference, the other

¹⁶ In any case, as the pioneer of the LP, it is not surprising that CBS would lack the incentive to pursue innovations that would challenge its own position, a phenomenon consistent with Kenneth Arrow’s (1962) “replacement effect” theory concerning monopolies’ lack of initiative to innovate.

¹⁷ As the equipment and plant to manufacture new audio formats had little alternative value, such “assets” would be deemed as highly specific. From a transaction cost economics framework, the options would be considered as highly risky, which may explain their hesitancy then. See Oliver Williamson (1981) for more on transaction costs and its relation to asset specificity issues.

¹⁸ The LP refers to the 12-inch long playing record that spins at 33½ RPM, a technology by Columbia, which was the incumbent while the challenger, RCA Victor, came out with its format, the 7-inch disk, that revolved at 45 RPM.

¹⁹ Many of the recording companies were huge and highly vertically integrated, from manufacturing (vinyl, cassettes and so on) to “artists-and-repertoire” (i.e., record “labels” that create music) to music publishing, not to mention having extended distribution networks in multiple countries. See Bakker (2006).

²⁰ While royalties were very low initially, for example, only three cents per disc in the case of US licensees in 1982, by 1995 it was five cents per disc despite the substantial drop in CD-manufacturing costs. In fact, by then, the cost of the license fees paid to the patent pool represented close to a third of the costs of manufacture for a CD-R. This ensured that the patent pool members (Philips and Sony) would dominate the CD-R market despite competition from other Asian firms (Kenneth Flamm 2013).

²¹ The success not only paved the way for the CD optical disc format to dominate the recorded music industry but in hindsight, the move had far-reaching effects than originally envisaged—the optical disc blueprint would go on to spawn many other related products across many industries, from data storage, books, entertainment, gaming and so on—from CD-ROM to CD-R/CD-RW to video CD and DVD.

being JVC's electrostatic system, the Philips-Sony system would reign victorious with its fortuitous success underlining the winner-takes-all premise in format wars, especially when the rents are highly appropriable (via patenting/licensing the innovation).²²

The CD's success story also highlights a key issue surrounding the management of innovation and commercialization of an invention: the massive developmental costs, expertise, and risk involved. On this issue, the success of the Philips-Sony collaboration and the subsequent commercialization (innovation) of the CD highlighted the efficacy of research and development alliances between firms, founded upon the principle of relational contracting, over in-house research and development activities.²³ From a resource-based theory perspective, the partnership made sense in that both were then at the frontier of optical disc research. Interestingly, both Philips and Sony did not find similar success in their respective projects immediately post-CD in the 1990s; Philips' digital compact cassette (DCC) format in the early 1990s did not penetrate the mainstream and was subsequently discontinued in 1996. Meanwhile, Sony's Mini Disc, a magneto-optical disc storage format intended as a replacement for analog cassette tapes, was slightly more successful but never dominated the industry. In any event, the Philips-Sony CD collaboration also reinforced some of the well-acknowledged characteristics of successful alliances—getting the right partner, chemistry and trust, and the willingness of parties to work things out when they go awry.²⁴ In fact, it was Noria Ohga, the then-executive deputy president of Sony Corporation and president of CBS/Sony, who saw the potential in the partnership—not only that Philips was already a world leader in optical videodiscs, while Sony led in digital audio signal processing technology, but also the fact that both owned record companies (Philips owned PolyGram while Sony had CBS/Sony Records). In fact, both had already worked together previously, having signed a free cross-licensing contract for video tape recorders in 1966 (Sony History). As such, they possessed a longstanding relationship based on trust and mutual respect:

Around the same time, Ohga received a telex from L.F. Ottens, a Philips technical executive. The message on the telex said, "If you happen to come to Europe, please visit us." Ohga had known Ottens since the mid-1960s, when Sony and Philips had successfully achieved the global standardization of the audio compact cassette. Since then, a strong relationship based on trust had developed between the executives of Sony and Philips ... (Sony History)²⁵

Their ability to work together was evident in some pivotal moments leading to the finalization of the CD format. For example, one pivotal issue was the number of quantization bits in which Philips insisted on 14 bits, but Sony argued for 16 bits. In terms of the disc size, Philips wanted a 11.5 cm disc (with 60 minutes of recording time) but Sony engineers were

²² See Sony History for more on the issues and technical challenges surrounding the Philips-Sony CD project in the run up to the 1981 Audio Conference in April that year.

²³ Relational contracting allows the circumvention of problems associated with formal contracting (e.g., the need to specify everything *ex ante*). This "flexibility" allows the contracting parties to utilize their detailed knowledge and adapt to changes and new information as the development process unfolds—this avoids potential *ex-post* haggling costs as argued in the transaction cost economics literatures.

²⁴ The Philips-Sony alliance embodies the view of Seungwha (Andy) Chung, Harbir Singh and Kyungmook Lee (2000), which looks at alliance formation based on status similarity and resource complementarity. For an extensive review of alliance types in the marketplace, see R. Duane Ireland, Michael A. Hitt and Deepa Vaidyanath (2002).

²⁵ In any case, Ronald Dore (1983), argued that trust in relational contracting is likely to be produced through social relationships and embedded ties. Such appears to be the case in the Philips-Sony alliance.

adamant on having 12 cm instead (with 75 minutes of recording time).²⁶ However, prior to the formal finalizations of the proposed standard, engineers from both sides were able to work things out amicably, and present a united front in insisting that their contributions were equal, avoiding taking credit for any specifics. Ultimately, the name of the system was coined as the *Compact Disc Digital Audio System*.

Convincing the Key Stakeholders

In terms of marketing, the key stakeholders that Philips and Sony needed to convince were the record companies, the artists, the retailers and, of course, the consumers. But regardless, the unique selling point of the CD was clear from the outset: product quality, which eventually won over all stakeholders. However, the introduction of CDs was not without controversies—its concepts of being “indestructible” and “able to ensure one’s music will last forever” were clearly overplayed and untrue. A. Schouhamer Immink, the principal engineer of the CD project at Philips, criticized the marketing, suggesting that the emphasis should instead have been the CD’s ease of handling and quality of sound (Lynskey 2015): its resolution of 16 bit/44.1kHz which ensured the replication of all frequencies that humans can theoretically hear.²⁷

Nonetheless, the resistance from recording companies was stronger than anticipated, and the initial pitch by Sony’s Ohga to executives of A&M Records was met with disdain and contempt, as John Nathan (1999) keenly documented. The music executives categorically dismissed the idea on the notion that the technology would kill the industry through piracy. However, the strong resistance from the industry would soon be overcome when the CD won over key artists, such as Stevie Wonder and Herbie Hancock. This soon set the tone for others to follow suit with the idea of going digital. Famed maestro Herbert von Karajan and Mark Knopfler (of the band Dire Straits) would also become leading advocates for digital technology thus lending it their reputations.²⁸ However, some artists eventually found that the success of the CD hurt their royalty revenues. As recounted by Michael Schulhof, former president of Sony Corp.’s US division, the then-head of CBS, Walter Yetnikoff, in pursuing the CD venture, made sure all artists agreed to contractual amendments allowing the issuance of their music on CD but with similar royalty payments as those on an LP, effectively ensuring lower royalty

²⁶ The final consensus on a 12 cm size was down to Ohga’s insistence on the ability to fit all of Beethoven’s Ninth Symphony on a single disc. A classical music aficionado, Ohga believed this was crucial and the move ensured that 95 percent of all classical music pieces could fit onto a disc (Sony History). The fact that most initial titles were classical albums when the CD was first introduced appears to support this claim. Curiously, the same was observed in the case of the LP when it was first introduced—this reflected the tastes of the early adopters in the market, i.e., more older and discerning consumers, who were able to afford the new technology. However, the much-publicized story of the insistence of Sony for the 12 cm size being down to the accommodation of the playing length of Beethoven’s Ninth Symphony was disputed by the Philips engineer Immink, who claimed that the decision came from the Philips’ side after much technical deliberation (Immink 1998).

²⁷ In technical terms, human hearing can capture sounds of between 20 hertz and 20,000 hertz. While CD and vinyl recording can reach 20,000 hertz easily, a cassette’s ability to capture high frequencies tends to tail off after 12,000 hertz (Lisa Hix 2015).

²⁸ Ohga’s persistence in driving the digital technology and CD would eventually pay off after a series of calculated risks. His appointment of Dr. Toshitada Doi, a jazz saxophonist who led the Sony team in their Philips collaboration on the CD, to oversee the development and marketing of the digital recording (and mastering equipment for studio use) eventually led to several top US artistes endorsing digital recordings. He also invested significantly in three CD manufacturing plants using profits from the CBS-Sony joint venture, one in Shizuoka Prefecture, another in Salzburg and one more in Indiana, US, in effect making CBS Records the first major record company to endorse the CD format. See Nathan (1999) for more.

rates for the artists, as CD prices, at least initially, were generally higher than LP prices (Knopper 2022).

Meanwhile, on the issue of production facilities, Sony built the first CD manufacturing plant in the United States in Terre Haute, Indiana. With a burgeoning CD market after a successful launch and marketing, CD sales grew and by the mid-1980s demand was outstripping production capacity. As first-movers into a largely untested market for CDs, PolyGram and Sony remained the two largest CD producers, with PolyGram alone producing a third of the world's CDs in 1986 (Philips Research). Since CD manufacturing capabilities/plants were highly specific assets (given CD's newness then), few recording firms had investments in this activity in the production chain thus allowing those with it to gain handsomely.²⁹ PolyGram and CBS/Sony therefore amassed huge profits from this new audio format not only via higher initial prices for CDs but also from manufacturing CDs (for others) given that there so few production options in the first few years following the format's introduction. As such, rival EMI lost significant revenue as a result of moving late into the CD format in the 1980s (Erik Gruijthuisen and Peter Junge 1992, 26-27), but once they proceeded with the adoption, the CD sales from their classical and pop titles were astounding.³⁰

In terms of the marketing of the CD to the end-users, the key features were many, from longer playing life (the use of a laser rather than a needle eliminated the usual wear and tear from excessive plays) to greater storage space, easier handling, and no need to flip sides as with LPs or cassettes. However, superior sound quality was the main selling point. Dire Straits' adoption of the CD for their 1985 album release, *Brothers in Arms*, was a huge success.³¹ The joint promotion between the band and Philips to promote the sound quality of CD to consumers made this the first album to log sales in excess of a million copies with the CD format (Dutch Audio Classics). Dire Straits' endorsement not only helped signal CDs as a product of quality but appealed especially to the fledging but growing "MTV generation" at the time.³²

Interestingly, the issue of singles and albums was a potential marketing conundrum for record companies in the days of the 45s (singles) and LPs (albums). The promotion of hit singles could drive album sales as well, hence the use of singles to promote albums. But in the case of weaker albums, the inclusion of several "singles" (i.e., songs that are deemed as potential hit singles) in an otherwise average album (i.e., the remaining numbers being "fillers") may actually hurt the sales of the singles.³³ However, the 45s, costing only about £2-3, appealed to many consumers, especially younger consumers and those only interested in an artist's hit songs. Further, 45s could generate additional revenue since they could come with remixes or other B-side tracks that were not included in the album (LP). In fact, many hit songs were driven in part by the popularity of their remix versions.³⁴ As such, they served as good advertisements for the albums. However, there was less dilemma in the case of CDs: albums were clearly more profitable than singles, given the negligible cost difference between them (H. Dean Hudson 2011). Record companies priced albums not much higher than singles, though they contained many more songs, and consumers responded accordingly: annual

²⁹ See also Bakker (2006).

³⁰ In the first 18 months following the adoption, EMI shipped over 2.5 million CDs (Southall 2009).

³¹ Knopfler had insisted on recording the album using state-of-the-art digital equipment (Lynskey 2015).

³² MTV, short for Music Television, launched on August 1, 1981 and originally aired only music videos. It quickly became a sensation among young people who were hooked on the cable television channel's broadcasting of music videos 24 hours a day, 7 days a week. It also heralded a new medium by which music could be enjoyed, and would go on to rival radio.

³³ A strategy known as a "weak unit strategy" (Mark Harvey 2016).

³⁴ Besides 45s, many remix versions of singles were released on 12-inch versions and went on to enormous chart success. A good example would be Duran Duran's 1984 megahit "The Reflex", the band's first number one hit on the Billboard Hot 100 largely thanks to an impressive remix treatment (Caulfield 2014).

sales of CD singles accounted for one percent or less of CD sales.³⁵ In fact, the marketing strategies of CDs were basically a value-added strategy in that many CD releases, especially the re-issues, often come with bonus tracks (e.g., previous non-album singles, and so on) or in the case of enhanced CDs, multi-media add-ons (e.g., music videos of the album's singles).³⁶ Given the influence of MTV, which coincidentally came about almost at the time of CD's entry, music videos have been an attractive add-on. Further, the marketing strategies often take the form of versioning—from deluxe versions to the low-priced editions, with consumers self-selecting based on their willingness to pay. Versions targeted at the more discerning group (i.e., price inelastic audiophiles/loyal fans) would include special boxset editions that come with several discs, from the standard album to other discs that include rarities, non-album B-sides, live versions and so on.

The advent of CDs also offered profitable opportunities to retailers, whether they were specialist music outlets or more general retailers such as supermarkets, newsagents, electrical good stores and so on.³⁷ For instance, in the UK, Woolworths introduced CD ranges in 200 of its stores during its mid-1980s major re-launch, expanding on its previous experience in stocking LPs in the 1960s, and then cassettes in the 1970s, to attract younger shoppers (Tennent and Mollan 2020). It appears that the CD roll-out encouraged even larger retailers, which may have contributed to impressive CD sales in the US and Japan.³⁸ The same trend, to a large extent, is also seen in the case of the UK market—see the trend in the UK album market total sales (in £) from 1975-2008 in Tschmuck (2017) and from 1955-1980 in Gourvish and Tennent (2010). The former notes that the expansionary phase of the UK recorded music production was from 1980-1996, with the period between 1983-1990 recording the highest annual average growth rates. These periods coincide with the CD's eras of growth and dominance. The major record labels also incentivized the switch by initiating an industry-wide return policy that led retailers to stop carrying the LP records and CDs to dominate the store racks (McLeod 2005). Still, the mass merchants/retailers that also sold audio equipment benefited from cross-selling as well.³⁹ Perhaps the biggest factor in the retailers' buy-in was the profitability of the CD: as Lynskey (2015) argues, the average price was \$14 during CD's supreme reign in the 1990s, yet the production cost was only a mere dollar. In addition, the

³⁵ I computed this figure using the RIAA data which reported CD singles sales from 1988-2016. Only from 1995-2000 did CD singles' annual sales volume represent three percent or more of CD (album/compilations) sales. On average (1988-2016), CD singles sales volume represented only 1.73 percent of CD sales volume.

³⁶ As CDs have a running time that easily exceeds the average length of an album, the inclusion of additional materials would be seen as value-added.

³⁷ Companies like EMI, Decca and Pye had over the years sought to take greater control over the value chain including retailing, for example, the use of rack jobbing in which full-price records carried by non-specialist retailers (like supermarkets) were subjected to greater scrutiny by the companies in effect leading to their control over which records were to be carried and where to display them. Meanwhile, some developments (like the formation of Record Merchandisers Ltd. to handle wholesaling), despite curtailing the powers of the major companies in appointing their own preferred retailers, expanded the industry even further in that more retailers could get involved and more importantly, in their preferred mode (i.e., to carry the full range or only the chart or budget material/range). See Tennent (2013) for a comprehensive historical account of music distribution in the UK from 1950-76.

³⁸ The role of retailers and supermarkets in driving music (e.g., LP, CD) sales is interesting and varied between countries, with some more pivotal than others given the different rates of development of supermarkets; for example, supermarkets in the US were developed much earlier than in the UK. This area would benefit from future research.

³⁹ This phenomenon was already evident even in the pre-CD era—in the 1970s, Woolworth in the UK, unlike its smaller retail competitors, was able to benefit from cross-selling since it also sold audio hardware besides the “software” like LPs and cassettes (Tennent and Mollan 2020).

labels were also working together with the retailers to avoid price drops so profits were massive then.

Market conditions would also figure in the push for the CD format as the music industry was going through a decline after the 1970s boom.⁴⁰ As such, a boost to the business was very much desired at the time. Although both professional resistance and consumer inertia were the major hurdles to the CD's progression, the latter, to a large extent was attributed to the prohibitive prices of the players to the average consumer.⁴¹ But ultimately, the CD succeeded because it was superior—it not only defeated the incumbents but also dominated the other prospectors at the time as well, for example, Telefunken's Mini Disc technology and an electrostatic system technology by JVC.⁴² Unsurprisingly, the CD was acknowledged as the most valued Philips innovation in 2015 by both the public and its employees while Philips itself was honoured with the IEEE milestone award in 2009 for the CD (Philips Research).

Market Share, Sales and Profitability

In this section, I analyse the data on the market share, total sales (both revenue and volume) and the price per unit for vinyl, cassette and CD. The data are sourced from the RIAA and RIAJ respectively. Tables 1 and 2 in the Data Appendix show the sales, revenue and average prices of the three formats in the US and Japan for the periods 1973-2020 and 1953-2020 respectively. I omitted some of the less significant formats in the comparative analysis—these being the vinyl single, cassette single, SACD (super audio CD), CD singles, DVD audio, other tapes and so on as their market shares were insignificant. However, in the interest of consistency, the Japanese data include the vinyl singles in the LP vinyl (i.e., album) figures and the CD singles in the CD figures as some portions of the data were aggregated while some others disaggregated (for example, from 1956-1993, the vinyl data are decomposed into the 7- and 12-inch figures but from 1994 onwards had only the figures listed under vinyl).⁴³

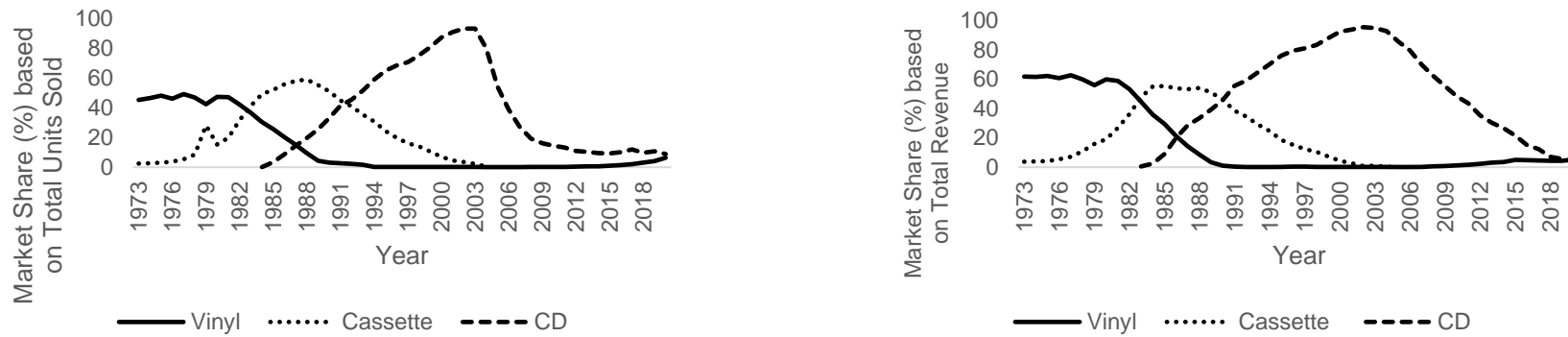
Table 1 shows the CD easily outperforming vinyl and cassettes in the US during the period from 1973-2020. Interestingly, all three formats had enjoyed market shares of up to 50 percent at some point in the timeline (see Figure 3), indicating the market's acceptance of format changes. I approach this issue by assessing the longevity of each format's market run, i.e., the number of years between a format's peak year to the year it registered less than 10 percent of the market share. I selected the total volume instead of total revenue to remove any price inflationary bias. From Table 1, the US data showed that it took vinyl 11 years (from a peak of 49.3 percent in 1977 to 9.5 percent in 1988) but it took 12 years for the cassette to fall below 10 percent (from a peak of 59.1 percent in 1988 to seven percent in 2000). The CD has been by far the most successful format in terms of longevity and unit sales—it fell from a high of 93.4 percent in 2002 to 9.8 percent in 2018 (i.e., 16 years). Given that it also dominated throughout the 1990s with an average of around 60 percent annually and the fact that it even outsold vinyl despite having only started its run in 1983 (from the available RIAA data)—its average of 390 million units far exceeds those of vinyl (83.79 million units) and cassette (187.67 million units), it is clear that CD has been the most successful physical format. In total, the CD has sold an astonishing 1.48 billion units since its introduction to the market in 1983

⁴⁰ John Qualen (1985) reported that the UK music industry was beginning to decline in the mid-1970s, with industry profitability also displaying similar downturn trends then.

⁴¹ The first CD player by Sony, the CDP-101, was released on October 1, 1982. It retailed at US\$1,000 (Bloomberg 2012). The item would cost around US\$2,600 in 2020 dollars.

⁴² Similarly, in the battle of formats in the vinyl era between Columbia's LP and RCA's 45s, the former went on to win the contest given its obvious superiority (New York Times 1964).

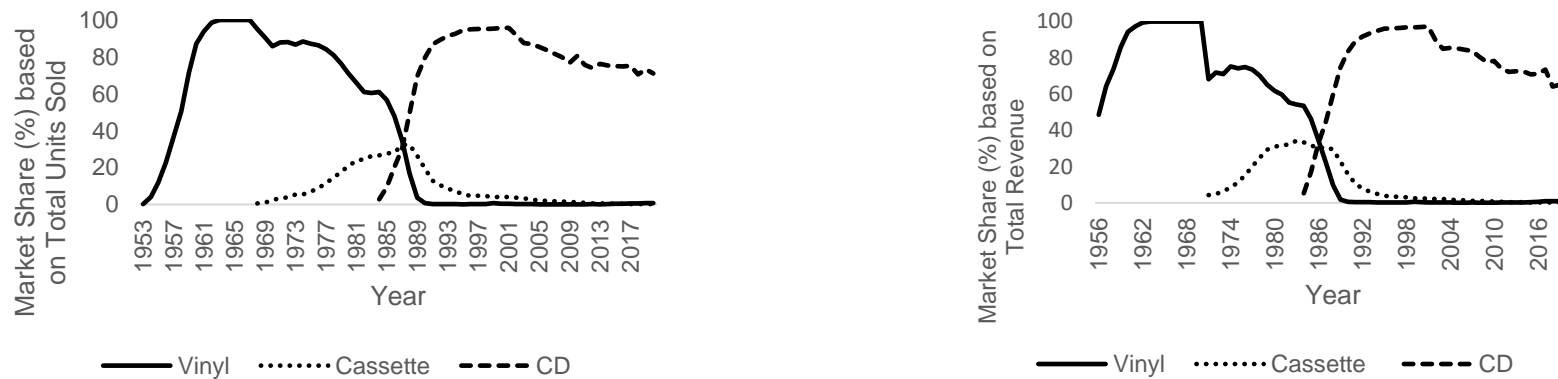
⁴³ The 7-inch vinyl are the vinyl singles but 12-inch may also be singles, these typically being remixed.



Source: author's calculations from data in Data Appendix Table 1

Figure 3

Market Share of Vinyl, Cassette and CD in US in terms of total units and total revenue



Source: author's calculations from data in Data Appendix Table 2

Figure 4

Market Share of Vinyl, Cassette and CD in Japan in terms of total units and total revenue

(see Data Appendix Table 3).⁴⁴

Japan's data (see Table 2) also reveal similar trends although cassettes' appeal did not match the levels seen in the US. Both vinyl and CD enjoyed total or virtual monopoly in the Japanese market at some point over the years.⁴⁵ Interestingly, the CD remains very popular in Japan in contrast to most other developed countries. As in the US, CDs in Japan outsold both vinyl and cassettes in an era where all three formats were widely available. From Table 2, the CD had the highest total sales (over 9 billion units) compared to vinyl (3.7 billion units) and cassette (1.2 billion units) even though it had the shortest run among the trio. Further, the longevity of the CD in Japan is even more pronounced relative to vinyl and cassette (compared to the US), with its share of the market still above 70 percent in the COVID-19-ravaged of 2020. Figure 4 shows the dominance of CD sales over the other physical formats in Japan, this in terms of their market share.

In terms of profitability, it is not hard to understand why the CD was once so revered by the retailers and recording companies—the marginal cost of producing these items was negligible and once demand increased considerably in the early- to mid-1990s, the substantial economies of scale created handsome profit margins. From Table 3, the average nominal price for a CD is US\$14.08. In fact, the price of a CD (in the US) was higher than vinyl from its inception in 1983 to 2005 (see Table 1). The standard deviation of the price for the CD over the period (at 1.98) also indicated that the price of CDs did not fluctuate as much as vinyl (6.99), underlining a more consistent and stable demand pattern—see Table 3. Adjusted for inflation, the average price for the CD is still the highest, at US\$8.68 compared to US\$8.27 and US\$6.98 for the LP and cassettes respectively.⁴⁶ Interestingly, the average real prices among them are quite similar, especially between the LP and CD, suggesting that technological advances did not lead to lower real prices for recorded music.⁴⁷ Meanwhile, I also calculated the coefficient of variation (CV) for CD, vinyl and cassette prices for both the US and Japan (see Table 3) to provide a better comparative measurement of risk among the three formats.⁴⁸ CV values (in both US and Japan) are lower for the CD than vinyl and cassette, indicating more stability in prices or in the context of finance theory, lower risk per dollar.

Huge margins and tight control over distribution and marketing, the latter due to the market power of the players (many of them being vertically integrated global multinationals with their own distribution channels), made CDs possibly the most lucrative product in the history of music (Lynskey 2015). At its peak in 2002 (in the US), the CD accounted for 95.5 percent of the industry total revenue while its share of total volume for that year was 93.4 percent (RIAA). In the case of Japan, the sales performance of the CD was even more pronounced—the CD's market share (in terms of volume) reached more than 70 percent within

⁴⁴ In terms of sales revenue, the CD's performance also easily dominated both cassettes' and vinyl's figures. In nominal terms, average CD sales revenue (from 1973-2020, although CD's run only began in 1983 while cassette's run ended in 2005) was more than 3.5 times the revenue of cassettes and 8.5 times of vinyl's. The ranking of average sales revenue performances is unchanged even after inflation—on average CD sales figures were still highest, this time, 2.5 times more than cassettes, and 4 times, in the case of vinyl. Table 3 reports the nominal figures.

⁴⁵ The virtual dominance of vinyl in Japan was more pronounced only because the Japanese data extend back to the 1950s, rather than 1973 for the US data.

⁴⁶ I computed the figures (covering the period 1973-2020) using RIAA data and CPI figures (US Bureau of Labor Statistics).

⁴⁷ However, this analysis does not include the hardware costs.

⁴⁸ The use of standard deviation may be undermined if the mean values of the variables involved are not the same, hence comparisons between them may not be meaningful. In this situation, a better option may be to use the coefficient of variation—this, when applied to investment assets, measures the risk per unit of return (see Eugene F. Brigham and Joel F. Houston 2004).

only a few years of its introduction (its market share reached 69.39 percent by 1989) and has remained above this level ever since.

In retrospect, the record companies' move to replace vinyl then made sense—the industry was moving towards a “rights-based business model” anyway (Bakker 2006; Qualen 1985). Later versions of the CD boasted enhanced features that could include multi-media add-ons, such as music videos or live performances, that could produce further profits from copyrighted materials with minimal additional production cost.

The CD's Impending Market Exit and Potential Lifecycle Extension

Despite its quick ascendance to market leadership, the CD began losing market share towards the end of the 2000s, with the drop being precipitous in recent years. In fact, the CD's situation is now akin to that of vinyl in the early 1990s (Laing 1992; Qualen 1985). The CD's digital disruption of the music industry led to further disruptions. Indeed, the digital transformations associated with online sharing platforms like Napster and YouTube were so pronounced that Volker Straebel (2009) argues that market power actually shifted from the major record labels to music consumers—forever altering the concept of sound recording and distribution.

While there is still a sense of nostalgia among some for the CD, most consumers have moved on, and so too have the suppliers of recorded music. Record stores in many countries have shuttered due to low sales, and in part due to the slower delivery of new titles as recording companies have shifted their focus from CD releases to music streaming. In fact, many new albums are no longer available on CD anymore. Further, the demand for CDs is also undermined in other related industries—for example, many automobile manufacturers no longer include CD players in their new models while desktop and laptop computers today are sold without disc drives. All these signal the market's (suppliers' and consumers') perceptions of a diminished preference for CDs, further undermining CD sales.

As argued earlier, continued demand for obsolete physical music formats such as vinyl, cassette and CD is based on the notion of these products being “nostalgic” or “cultural” goods. While they can also be compared to other types of such goods (like vintage cars or retro toys), it is likely that the market will demand new production of them as well, hence a “revival” in their product life-cycle curves despite having totally exited the market at one stage. Such resilience can be attributed to the investment of cultural value earlier in their product life cycle.

A good case in point is vinyl—besides enjoying an active used market, it is also enjoying a new life with new pressings and new re-issues. In fact, the last few years have seen vinyl sales hitting record highs (Will Richards 2021). Given that a similar though lesser trend is also observed in the case of cassette, the notion of a future revival for the CD should not be totally dismissed.⁴⁹ The fact that many grew up with the format (e.g., millennials or even the older generation-X whose adolescent years coincided with the CD's reign) does suggest a potentially huge market.

In a way, the CD and vinyl are both being not only “nostalgic goods” but also goods which exhibit what Janice Denegri-Knott and Mike Molesworth (2010) call “curatorial consumption”. In the case of the former, a product that can fulfil one's longing to a place of desire in the past while the latter, an obsession with curating a collection. Denegri-Knott and Molesworth (2010) applied the concept to MP3 music playlist curation based on moods or genres. In the context of vinyl and the CD, such curatorial consumption would entail not only intimate listening but also the obsession of collecting all the desired titles of, say, a favourite band or a particular genre. This is not surprising, given that many vinyl enthusiasts are known to collect not only favourite titles but also specific pressings (e.g., early pressings). In the case

⁴⁹ This phenomenon explains the popularity of cultural events like the *Record Store Day* and *Cassette Store Day*.

of CD, amassing of collectibles may be just as intensive—by artists (the catalogue of releases for an artist tends to be more extensive for CD—album titles, hordes of compilation albums, special boxset editions), by genre (e.g., rock, new wave), and so on.

The extended life-cycle of physical music formats captures the “rights-based business model” of the industry eloquently in the constant exploitations of them by the music companies—the vinyl renaissance was certainly a good excuse for them to embark on album re-issues (for example, Universal Music’s Back to Black series). In essence, nostalgic goods are deemed precious to those who experienced the intensity of the product’s influence at the time, in what Cross (2017) identifies as “capturing the aura of that brief moment”. Many (music lovers) who grew up in the late 1980s and throughout the 1990s would connect most strongly with CDs. If so, it may not be the end for the CD just yet—a “revival” stage post-“decline” stage in its product’s life cycle curve is possible, akin to what we are seeing in the case of vinyl. Figures 3 and 4 illustrate vinyl’s market share curve showing slight upturns (in 2013 and beyond) after its decline stage (i.e., from 1991-2013), suggesting an extension to its product life-cycle curve.⁵⁰ That said, the effect appears to be smaller in the case of cassette, this due to its revival being on a smaller scale and possibly, the absence of data reporting. As for the CD, it is still very much in the “decline” stage now, so a revival has yet to take place (Daniel 2019).

Conclusion

The CD’s place in history is guaranteed, both in the context of the recorded music industry and our lives in general. It was, for a time, the definitive medium in which popular music was enjoyed, and its technology set the stage for a plethora of other products that are associated with so many facets of our lives, from information storage to entertainment and gaming, to identify a few. This article reflects on the development of the CD, from a promising invention to commercialization, the challenges it faced and the unique factors responsible for its success. While the eventual success of the CD as an audio format can be attributed to effective strategies by those involved, organization reputation coupled with architecture also played a part in winning the format war and subsequent appropriation of the economic rents. Further, the CD was also a crucial element in the evolution of the business model in the recorded music industry—exploitation of music rights through the CD proved to be the most profitable phase in the industry’s history. While its amazing run is in its final lap, all may not be lost as the CD, being a cultural/nostalgic good, may boast of an extension in its product life cycle. If so, the story of the CD may not have reached its concluding chapter just yet.

Works Cited

- Arditi, David. 2014. *iTake-Over: The Recording Industry in the Digital Era*. Lanham, MD: Rowman & Littlefield.
- Arrow, Kenneth. 1962. “Economic Welfare and the Allocation of Resources for Invention.” In *The Rate and Direction of Inventive Activity: Economic and Social Factors*, 609-626. National Bureau of Economic Research. Princeton, NJ: Princeton University Press.
- Bakker, Gerben. 2006. “The Making of a Music Multinational: PolyGram’s International Businesses 1945-1988.” *Business History Review* 80 (1): 81-123.

⁵⁰ The traditional model of a product’s existence in the market consists of four stages, they defining a product’s life-cycle starting with the introduction stage followed by the growth stage and then the mature stage before curtailing into the decline stage.

- Bloomberg. 2012. "Play/Pause: A Look at 30 Years of the Compact Disc." October 2. Accessed July 28, 2021. <https://www.bloomberg.com/news/photo-essays/2012-10-01/play-pause-a-look-at-30-years-of-the-compact-disc>.
- Brigham, Eugene F. and Joel F. Houston. 2004. *Fundamentals of Financial Management*. 10th edition, South Western, Thomson Learning.
- Caulfield, Keith. 2014. "30 Years Ago Today: Duran Duran's 'The Reflex' Hit No. 1 on the Hot 100." *Billboard*, June 23. Accessed July 3, 2022. <https://www.billboard.com/pro/duran-duran-reflex-hot-100-anniversary/>.
- Chung, Seungwha (Andy), Harbir Singh, and Kyungmook Lee. 2000. "Complementarity, Status Similarity and Social Capital as Drivers of Alliance Formation." *Strategic Management Journal* 21 (1): 1-22
- Daniel, Ryan. 2019. "Digital Disruption in the Music Industry: The Case of the Compact Disc." *Creative Industries Journal* 12 (2): 159-166.
- Denegri-Knott, Janice and Mike Molesworth. 2010. "Concepts and Practices of Digital Virtual Consumption." *Consumption, Markets & Culture* 13 (2): 109-132.
- Dore, Ronald. 1983. "Goodwill and the Spirit of Market Capitalism." *British Journal of Sociology* 34 (4): 459-482.
- Dutch Audio Classics. "Philips CD 25 Year Anniversary." Accessed July 23, 2021. https://dutchaudioclassics.nl/philips_press_cd_25_year_anniversary_2007/.
- Feldman, Len. 1984. "Prices Down, Quality Up: Hot New Compact-Disc Players." *Popular Science* 101-103.
- Flamm, Kenneth. 2013. "A Tale of Two Standards: Patent Pools and Innovation in the Optical Disk Drive Industry." NBER Working Paper Series, Working Paper 18931.
- Geroski, Paul A. 2003. "Competition in Markets and Competition for Markets." *Journal of Industry, Competition and Trade* 3 (3): 151-166.
- Gourvish, Terry and Kevin Tennent. 2010. "Peterson and Berger Revisited: Changing Market Dominance in the British Popular Music Industry, c. 1950-80." *Business History* 52 (2): 187-206.
- Gronow, Pekka. 1987. "Shorter Notices: The Music Industry: The End of Vinyl?" *Popular Music* 6 (1): 122-123, January.
- Gruijthuisen, Erik and Peter Junge. 1992. *De Revolutie van Jan Timmer*. [The Revolution of Jan Timmer.] Naarden, Netherlands: Strengholt.
- Harvey, Mark 2016. "The Rise of the LP: The Politics of Diffusion Innovation in the Recording Industry." *Business History* 58 (7): 1095-1117.
- Hix, Lisa. 2015. "Cassette Revolution: Why 1980s Tape Tech is Still Making Noise in Our Digital World." *Collectors Weekly*, June 2. Accessed January 7, 2020. <https://www.collectorsweekly.com/articles/cassette-revolution/>.
- Hochman, Steve. 1988. "Will Those Vinyl Records Be All Played Out by 1990?" *Los Angeles Times*, October 8.
- Hudson, H. Dean. 2011. "Disruptive Distributions in the Music Business, Part 1: An Historical Perspective." *The Four Peaks Review* 1.1: 37-48.
- Hull, Geoffrey P., Thomas W. Hutchison, and Richard Strasser. 2011. *The Music Business and Recording Industry*. New York: Routledge.
- Immink, Kees A. Schouhamer. 1998. "Compact Disc Story." *Journal of the Audio Engineering Society* 46 (5): 458-460, 462, 464.
- Ireland, R. Duane, Michael A. Hitt, and Deepa Vaidyanath. 2002. "Alliance Management as a Source of Competitive Advantage." *Journal of Management* 28 (3): 413-446.
- Knopper, Steve. 2022. "The CD Turns 40: How the 'Shiny, Tiny' Discs Took Over." *Billboard*, October 1. Accessed July 3, 2022. <https://www.billboard.com/pro/cd-history-music-business-format-40-years/>.
- Laing, Dave. 1992. "A Farewell to Vinyl?" *Popular Music* 11 (1): 109-110.

- Lynskey, Dorian. 2015. "How the Compact Disc Lost its Shine." *The Guardian*, May 28. Accessed March 1, 2020. <https://www.theguardian.com/music/2015/may/28/how-the-compact-disc-lost-its-shine>.
- Markides, Constantinos. 2006. "Disruptive Innovation: In Need of Better Theory." *Journal of Product Innovation Management* 23 (1): 19-25.
- McLeod, Kembrew. 2005. "MP3s Are Killing Home Taping: The Rise of Internet Distribution and its Challenge to the Major Label Music Monopoly." *Popular Music and Society* 28 (4): 521-531.
- Nathan, John. 1999. *Sony: The Private Life*. Boston, MA: Houghton Mifflin Company.
- New York Times*. 1964. "The Battle of Tape Speeds". November 8. Accessed August 2, 2021. <https://www.nytimes.com/1964/11/08/archives/the-battle-of-tape-speeds.html>.
- Philips Research. "The History of the CD—The Beginning." Accessed July 14, 2021. <https://www.philips.com/a-w/research/technologies/cd/beginning.html>.
- Qualen, John. 1985. *The Music Industry: End of Vinyl?* London: Comedia.
- Richards, Will. 2021. "Vinyl Record Sales in 2021 at Highest Level for 30 Years." *NME*, December 29, 2021. Accessed April 14, 2023. <https://www.nme.com/news/music/vinyl-record-sales-in-2021-at-highest-level-for-30-years-3127074>.
- The Recording Industry Association of America (RIAA). *US Sales Database*. Data accessed during the period July 2021 to June 2022. <https://www.riaa.com/u-s-sales-database/>.
- The Recording Industry Association of Japan (RIAJ). *Annual Data*. Data accessed during the period July 2021 to June 2022. <https://www.riaj.or.jp/f/e/data/annual/index.html>.
- Schumpeter, Joseph. 1942. *Capitalism, Socialism and Democracy*. New York: Harper & Bros.
- Sony History. "Chapter 8: This Will Replace the LP Record." Accessed July 23, 2021. <https://www.sony.com/en/SonyInfo/CorporateInfo/History/SonyHistory/2-08.html>.
- Southall, Brian. 2009. *The Rise and Fall of EMI Records*. London: Omnibus Press.
- Straebel, Volker. 2009. "From Reproduction to Performance: Media-Specific Music for Compact Disc." *Leonardo Music Journal* 19: 23-30.
- Tennent, Kevin D. 2013. "A Distribution Revolution: Changes in Music Distribution in the UK 1950-76." *Business History* 55 (3): 327-347.
- Tennent, Kevin D. and Simon M. Mollan. 2020. "The Limits of the Narratives of Strategy: Three Stories from the History of Music Retail." *Management & Organizational History* 15 (3): 273-294.
- Tschmuck, Peter. 2017. "The UK Recorded Music Market in a Long-Term Perspective, 1975-2016." *Music Business Research*. Accessed May 12, 2022. <https://musicbusinessresearch.wordpress.com/tag/uk-recorded-music-market/>.
- Tschmuck, Peter. 2009. "Copyright, Contracts and Music Production." *Information, Communication & Society* 12 (2): 251-266.
- US Bureau of Labor Statistics. "CPI for All Urban Consumers. CPI-U." Accessed April 1, 2023. https://data.bls.gov/timeseries/CUUR0000SA0?amp%253bdata_tool=XGtable&output_view=data&include_graphs=true.
- Waldman, Michael. 2003. "Durable Goods Theory for Real World Markets." *Journal of Economic Perspectives* 17 (1): 131-154.
- Waniata, Ryan. 2018. "The Life and Times of the Late, Great CD." *Digital Trends*, February 7. Accessed July 4, 2021. <https://www.digitaltrends.com/features/the-history-of-the-cds-rise-and-fall/>.
- Williamson, Oliver. 1981. "The Modern Corporation: Origins, Evolution, Attributes." *Journal of Economic Literature* 19 (4): 1537-1568
- Yale University Library. "The History of 78 RPM Recordings." Accessed May 11, 2022. <https://web.library.yale.edu/cataloging/music/historyof78rpms>.

Data Appendix

Table 1

Annual Sales (Volume and Revenue) and Price of Vinyl, Compact Cassette and Compact Discs in the US (1973-2020)

Year	Vinyl (LP/EP)			Compact Cassette			Compact Disc		
	Annual Sales Volume (million)	Annual Revenue (\$ millions)*	Average Price per Unit (US\$)*	Annual Sales Volume ('million)	Annual Revenue (\$ millions)*	Average Price per Unit (US\$)*	Annual Sales Volume (million)	Annual Revenue (\$ millions)*	Average Price per Unit (US\$)*
1973	280.0	1200	4.29	15.0	76.0	5.07	-	-	-
1974	276.0	1400	5.07	15.3	87.2	5.70	-	-	-
1975	257	1500	5.84	16.2	98.8	6.10	-	-	-
1976	273.0	1700	6.23	21.8	145.7	6.68	-	-	-
1977	344.0	2200	6.40	36.9	249.6	6.76	-	-	-
1978	341.3	2500	7.32	61.3	449.8	7.34	-	-	-
1979	290.0	2100	7.24	78.5	580.6	7.40	-	-	-
1980	308.0	2200	7.14	99.0	705	7.12	-	-	-
1981	295.2	2300	7.79	124.0	1100	8.87	-	-	-
1982	243.9	1900	7.79	183.2	1400	7.64	-	-	-
1983	209.6	1700	8.11	236.8	1800	7.60	0.8	17.2	21.50
1984	204.6	1500	7.33	332	2400	7.23	5.8	103.3	17.81
1985	167	1300	7.78	339.1	2400	7.08	22.6	389.5	17.23
1986	125.2	983	7.85	344.5	2500	7.26	53.0	930.1	17.55
1987	107	793.1	7.41	410	3000	7.32	102.1	1600	15.67
1988	72.4	532.2	7.35	450.1	3400	7.55	149.7	2100	14.03
1989	34.6	220.3	6.37	446.2	3300	7.40	207.2	2600	12.55
1990	11.7	86.5	7.39	442.2	3500	7.91	286.5	3500	12.22
1991	4.8	29.4	6.13	360.1	3000	8.33	333.3	4300	12.90
1992	2.3	13.5	5.87	366.4	3100	8.46	407.5	5300	13.01
1993	1.2	10.6	8.83	339.5	2900	8.54	495.4	6500	13.12
1994	1.9	17.8	9.37	345.4	3000	8.69	662.1	8500	12.84
1995	2.2	25.1	11.41	272.6	2300	8.44	722.9	9400	13.00

Lee: The Audio Compact Disc

Year	Vinyl (LP/EP)			Compact Cassette			Compact Disc		
	Annual Sales Volume (million)	Annual Revenue (\$ millions)*	Average Price per Unit (US\$)*	Annual Sales Volume (million)	Annual Revenue (\$ millions)*	Average Price per Unit (US\$)*	Annual Sales Volume (million)	Annual Revenue (\$ millions)*	Average Price per Unit (US\$)*
1996	2.9	36.8	12.69	225.3	1900	8.43	778.9	9900	12.71
1997	2.7	33.3	12.33	172.6	1500	8.69	753.1	9900	13.15
1998	3.4	34.0	10.00	158.5	1400	8.83	847	11400	13.46
1999	2.9	31.8	10.97	123.6	1100	8.90	938.9	12800	13.63
2000	2.2	27.7	12.59	76	626	8.24	942.5	13200	14.01
2001	2.3	27.4	11.91	45	363.4	8.08	881.9	12900	14.63
2002	1.7	20.5	12.06	31.1	209.8	6.75	803.3	12000	14.94
2003	1.5	21.7	14.47	17.2	108.1	6.28	746	11200	15.01
2004	1.4	19.3	13.79	5.2	23.7	4.56	767	11400	14.86
2005	1.0	14.2	14.20	2.5	13.1	5.24	705.4	10500	14.89
2006	0.9	15.7	17.44	-	-	-	619.7	9400	15.17
2007	1.3	22.9	17.62	-	-	-	499.7	7500	15.01
2008	2.9	56.7	19.55	-	-	-	368.4	5500	14.93
2009	3.5	63.8	18.23	-	-	-	296.6	4300	14.50
2010	4.2	88.9	21.17	-	-	-	253	3400	13.44
2011	5.5	119.4	21.71	-	-	-	240.8	3100	12.87
2012	6.9	160.7	23.29	-	-	-	198.2	2500	12.61
2013	9.4	210.7	22.41	-	-	-	173.8	2100	12.08
2014	10.3	243.8	23.67	-	-	-	138.7	1800	12.98
2015	13.7	333.4	24.34	-	-	-	117.1	1400	11.96
2016	14.8	355.4	24.01	-	-	-	97.6	1100	11.27
2017	15.6	388.5	24.90	-	-	-	86.7	1000	11.53
2018	16.7	419.2	25.10	-	-	-	51.8	695.8	13.43
2019	18.5	479.5	25.92	-	-	-	47.5	630.7	13.28
2020	22.9	619.6	27.06	-	-	-	31.6	483.3	15.29

Source: Recording Industry Association of America (RIAA)

Notes: *Unadjusted for inflation. The average price per unit is derived from annual revenue divided by annual sales volume.

Table 2
Annual Sales (Volume and Revenue) and Price of Vinyl, Compact Cassette and Compact Discs in Japan (1953-2020)

Year	Vinyl (LP/EP)			Compact Cassette			Compact Disc		
	Annual Sales Volume ('000)	Annual Revenue (¥ millions)*	Average Price per Unit (¥)*	Annual Sales Volume ('000)	Annual Revenue (¥ millions)*	Average Price per Unit (¥)*	Annual Sales Volume ('000)	Annual Revenue (¥ millions)*	Average Price per Unit (¥)*
1953	52	-	-	-	-	-	-	-	-
1954	664	-	-	-	-	-	-	-	-
1955	1719	-	-	-	-	-	-	-	-
1956	3398	1,973	580.64	-	-	-	-	-	-
1957	5710	3,198	560.07	-	-	-	-	-	-
1958	8681	4,224	486.58	-	-	-	-	-	-
1959	13853	5,959	430.16	-	-	-	-	-	-
1960	20926	8,455	404.04	-	-	-	-	-	-
1961	30846	12,228	396.42	-	-	-	-	-	-
1962	43154	17,154	397.51	-	-	-	-	-	-
1963	59570	20,915	351.10	-	-	-	-	-	-
1964	73813	25,190	341.27	-	-	-	-	-	-
1965	90934	29,393	323.23	-	-	-	-	-	-
1966	94490	31,965	338.29	-	-	-	-	-	-
1967	100100	34,647	346.12	-	-	-	-	-	-
1968	120431	49,245	408.91	631	-	-	-	-	-
1969	133572	60,369	451.96	1,250	-	-	-	-	-
1970	133555	65,720	492.08	3,790	-	-	-	-	-
1971	150311	76,577	509.46	5,837	4,879	835.87	-	-	-
1972	152050	83,281	547.72	6,770	5,628	831.31	-	-	-
1973	172261	107,551	624.35	10,591	10,007	944.86	-	-	-
1974	181659	132,425	728.98	11,154	14,542	1303.75	-	-	-
1975	177371	137,134	773.15	14,090	20,997	1490.21	-	-	-
1976	199752	163,562	818.83	20,187	33,402	1654.63	-	-	-
1977	184063	163,539	888.49	25,612	44,723	1746.17	-	-	-

Lee: The Audio Compact Disc

Year	Vinyl (LP/EP)			Compact Cassette			Compact Disc		
	Annual Sales Volume ('000)	Annual Revenue (¥ millions)*	Average Price per Unit (¥)*	Annual Sales Volume ('000)	Annual Revenue (¥ millions)*	Average Price per Unit (¥)*	Annual Sales Volume ('000)	Annual Revenue (¥ millions)*	Average Price per Unit (¥)*
1978	196228	172,208	877.59	34,855	61,371	1760.75	-	-	-
1979	198804	171,399	862.15	46,220	76,993	1665.79	-	-	-
1980	194943	181,238	929.70	57,107	90,341	1581.96	-	-	-
1981	168534	172,407	1022.98	60,627	91,718	1512.82	-	-	-
1982	151916	155,292	1022.22	61,115	90,594	1482.35	-	-	-
1983	148736	152,682	1026.53	64,618	96,691	1496.35	-	-	-
1984	139339	146,570	1051.90	60,917	91,406	1500.50	6365	14,439	2268.50
1985	124516	130,246	1046.02	60,694	89,453	1473.84	20638	47,931	2322.46
1986	106050	103,305	974.12	62,517	89,220	1427.13	45120	97,912	2170.04
1987	73995	69,933	945.10	68,925	96,295	1397.10	64992	139,016	2138.97
1988	39463	33,206	841.45	76,074	100,812	1325.18	115537	205,248	1776.47
1989	10056	7,142	710.22	72,301	87,752	1213.70	190518	286,761	1505.16
1990	2332	1,855	795.45	56,541	61,872	1094.29	230949	323,349	1400.09
1991	982	1,484	1511.20	44,579	47,714	1070.32	299273	399,796	1335.89
1992	1014	1,853	1827.42	38,853	37,819	973.39	333230	438,531	1316.00
1993	842	1,522	1807.60	35,333	31,689	896.87	381551	480,464	1259.24
1994	620	1,081	1743.55	29,860	25,924	868.18	379970	492,241	1295.47
1995	534	881	1649.81	25,031	21,982	878.19	439950	551,169	1252.80
1996	944	1,312	1389.83	22,512	19,969	887.04	448850	562,582	1253.39
1997	1034	1,369	1323.98	22,534	19,573	868.60	457140	567,078	1240.49
1998	1186	1,484	1251.26	21,818	18,132	831.06	457173	587,878	1285.90
1999	2985	3,575	1197.65	17,608	14,680	833.71	423757	551,296	1300.97
2000	1914	2,069	1080.98	17,174	13,868	807.50	414052	523,879	1265.25
2001	1297	1,351	1041.63	15,160	12,132	800.26	368626	489,578	1328.12
2002	697	782	1121.95	12,972	10,542	812.67	328679	431,806	1313.76
2003	580	676	1165.52	11,733	9,867	840.96	315267	387,988	1230.66
2004	894	520	581.66	8,999	7,437	826.43	302256	368,611	1219.53

Essays in Economic & Business History 41 (1) 2023

Year	Vinyl (LP/EP)			Compact Cassette			Compact Disc		
	Annual Sales Volume ('000)	Annual Revenue (¥ millions)*	Average Price per Unit (¥)*	Annual Sales Volume ('000)	Annual Revenue (¥ millions)*	Average Price per Unit (¥)*	Annual Sales Volume ('000)	Annual Revenue (¥ millions)*	Average Price per Unit (¥)*
2005	306	406	1326.80	7,425	6,322	851.45	301804	359,800	1192.16
2006	248	337	1358.87	6,665	5,613	842.16	290252	344,518	1186.96
2007	324	563	1737.65	5,557	4,506	810.87	260341	327,174	1256.71
2008	212	352	1660.38	4,586	3,740	815.53	242451	291,265	1201.34
2009	102	190	1862.75	3,777	2,943	779.19	210059	245,971	1170.96
2010	105	170	1619.05	2,866	2,300	802.51	206539	222,034	1075.02
2011	210	336	1600.00	2,104	1,727	820.82	196563	208,500	1060.73
2012	453	673	1485.65	1,800	1,461	811.67	215169	224,631	1043.97
2013	268	408	1522.39	1,387	1,144	824.80	188737	196,186	1039.47
2014	401	678	1690.77	1,071	905	845.00	170383	184,088	1080.44
2015	662	1,175	1774.92	800	695	868.75	167840	180,110	1073.11
2016	799	1,455	1821.03	700	614	877.14	159223	174,873	1098.29
2017	1063	1,916	1802.45	571	482	844.13	152294	170,654	1120.56
2018	1116	2,077	1861.11	441	382	866.21	137268	154,199	1123.34
2019	1219	2,146	1760.46	336	318	946.43	132325	149,548	1130.16
2020	1095	2,117	1933.33	291	210	721.65	103932	126,938	1221.36

Source: Recording Industry Association of Japan (RIAJ).

Notes: *Unadjusted for inflation. The average price per unit is derived from annual revenue divided by annual sales volume.

Lee: The Audio Compact Disc

Table 3
Descriptive Statistics (US and Japan data)

US									
	Vinyl			Compact Cassette			Compact Disc		
	Annual Sales Volume, million (1973-2020)	Annual Sales Revenue, \$ millions (1973-2020)	Price (1973-2020) US\$	Annual Sales Volume million (1973-2020)	Annual Sales Revenue \$ millions (1973-2020)	Price (1973-2020) US\$	Annual Sales Volume million (1983-2020)	Annual Sales Revenue \$ millions (1983-2020)	Price (1983-2020) US\$
Max	344	2500	27.06	450.1	3500	8.90	942.5	13200	21.50
Min	0.9	10.6	4.29	2.5	13.1	4.56	0.8	17.2	11.27
Std Dev	119.23	786.48	6.99	155.83	1224.30	1.15	315.60	4473.87	1.98
Mean	83.79	626.18	13.08	187.67	1476.87	7.41	390.37	5403.94	14.08
CV	1.42	0.80	0.53	0.83	0.83	0.22	0.81	0.83	0.14
Total	4022	30056.4	-	6193.1	48736.8	-	14834.1	205349.9	-
Japan									
	Vinyl			Compact Cassette			Compact Disc		
	Annual Sales Volume million (1953-2020)	Annual Sales Revenue ¥ millions (1956-2020)	Price (1956-2020) ¥	Annual Sales Volume million (1968-2020)	Annual Sales Revenue ¥ millions (1971-2020)	Price (1971-2020) ¥	Annual Sales Volume million (1984-2020)	Annual Sales Revenue ¥ millions (1984-2020)	Price (1984-2020) ¥
Max	199.75	181,238	1933.33	76.07	100812	1760.75	457.17	587878	2322.46
Min	0.05	170	323.23	0.63	210	721.65	6.37	14439	1039.47
Std Dev	71.42	60697.96	512.58	23.97	35228.58	320.25	128.43	162892.75	342.53
Mean	54.88	42571.46	1058.71	23.53	31667.72	1065.24	247.54	311028.16	1339.29
CV	1.30	1.43	0.48	1.02	1.11	0.30	0.52	0.52	0.26
Total	3731.95	2,767,145	-	1246.97	1,583,386	-	9159.07	11,508,042	-

Source: author's calculations from data in Tables 1 and 2.

Note: The figures above are unadjusted for inflation.